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DRAWINGS ATTACHED

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(54) IMPROVEMENTS IN OR RELATING TO EXPLOSIVE CHARGES

(71) We, ETAT FRANCAIS, represented by the Minister of the Armed Forces, The Ministerial Delegation for Armaments (Directorate of Research and Testing), of 10 Rue Saint-Dominique, Paris 7e, France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to longitudinally-extending explosive charges suitable for use in, for example, civil engineering works and mining work requiring precutting shots the object of which it is to prevent the slipping of rock beyond the required line and to initiate fissures in the cut rock; and to a method for the manufacture of such explosive charges.

According to a known precutting technique, the establishment of shearing planes in the rock mass is proceeded to before drilling and then using explosives to blast the rock located within predetermined rupture lines. To this end, holes are drilled on the rupture lines with uniform spacing which is substantially proportional to the diameter of the drill holes, the diameter generally being less than 200 mm. The drill holes, which are parallel, are then charged with small quantities of explosives the volume of which corresponds fairly frequently to less than 10% of the cavity. The large volume which is then offered for detonation may result in an explosive pressure which is inadequate for fissuring the rock; thus, the precaution is taken, after having lodged the explosive, of reducing the expansion volume by filling the cavity with, for example, sifted gravel and it is with the same end in view that effective tamping is performed at the drill hole orifices.

The explosion of the charges or mines distributed throughout all or in only part of the drill holes is required to evolve an amount of energy which in itself is sufficient to crush the area of rock between two succesisve mines. The result is the creation of a trench or "cut" against which the subsequent blasting explosions will have greatly reduced disaggregation and shock effects beyond the said trench or cut, so that the wall which are cut will be substantially plane and unfissured.

According to a first known method, the explosive charge is a detonating fuse on which are secured cartridges made, from, for example, gelatine-dynamite, introduced into the drill hole. The spacing between the latter permits the desired dosing. This discon-continuous charging method, which is carried into effect in the workings, has the disadvantage that it is dangerous, lengthy and consequently costly; furthermore, it is possible only in drill holes the inclination of which to the vertical is less than 20°.

According to a second known method, the explosive charge is a continuous, i.e. one-piece, charge constituted by a reinforced detonating fuse containing, as the explosive, penthrite. Although it has the advantage that it is readily carried into effect, this further method nevertheless has serious disadvantages. In fact, the diameter of fuses of this type is limited for technical reasons, so that it is impossible to employ them in unitary fashion in drill holes having a diameter greater than 90 mm., since they insufficiently fill the drilled cavity; it is then necessary to diminish the spacing of the holes and the operation then becomes costly. It is possible to obviate this difficulty in the case of drill holes having a diameter greater than 90 mm., by using a plurality of detonating fuses for one and the same drill hole; but, in this latter case, the positioning is more laborious. Furthermore, the reinforced detonating fuse has the disadvantage that it is expensive.

According to a third known method, the explosive charge is a continuous charge which is constituted by a highly sensitive explosive packed in threaded cartridges of small diameter. The technical limitation of the diameter here requires the drilling of drill holes the diameter of which is greater than 60 mm. Furthermore, this arrangement has the dis-

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advantage that it employs a highly sensitive and therefore dangerous explosive.

According to one aspect of the present invention, there is provided a longitudinally-extending explosive charge comprising a flexible sheath, a pourable explosive contained in the flexible sheath, and a detonating fuse extending through the sheath, made fast to the sheath at the end regions of the latter and extending beyond the sheath at at least one end of the sheath.

In a preferred embodiment, the explosive is a mixture of ammonium nitrate and a fuel, which has the advantage of being only slightly sensitive and not too costly.

Again in a preferred manner, the flexible sheath is a cylindrical sheath made of a plastics material. The plastics material is preferably polyethylene.

The detonating fuse is advantageously a single 12 grammes per metre fuse.

In a preferred embodiment of the invention, the explosive may be mixed with a diluent. The diluent, which is inert or only weakly active, and is generally in powdered form, allows variation of the percentage of explosive and consequently makes it possible to influence the linear power of the explosive charge. Thus, the addition of the diluent enables the adjustment of the power of the explosion as a function of the working conditions. Preferably, the diluent is wood flour.

According to another aspect of the present invention, there is provided a method for the manufacture of the explosive charge according to the present invention, which comprises introducing into one end of a flexible sheath a tube connected to a pneumatic charging apparatus, feeding compressed air into the sheath through the tube during an outward travel movement thereof, whilst causing the compressed air from the tube to entrain a dentonating fuse, and, once the tube has reached the other end region of the sheath, fastening the detonating fuse to the sheath in a region of the other end of the sheath, and withdrawing the tube meanwhile causing it to deliver, during its return travel movement, a pourable explosive and optionally a diluent, so as to fill the sheath, and fastening the detonating fuse to the sheath in the region of the said one end of the sheath.

In preferred embodiment, the advance of the detonating fuse within the sheath is obtained by securing a light body, such as a washer or a plug or stopper made of wood or the like, to the end of the fuse. The said weight, subjected to the pressure of the compressed air flowing out through the tube, advances progressively in the sheath and entrains the fuse during its displacement.

According to one embodiment, the process of manufactutre is applied to the manufacture of unitary explosive charges. In this case, the return movement of the tube is initiated only after ligature of the sheath on the end of the detonating fuse passing out to the exterior, at the end of the outward travel movement.

According to an alternative embodiment, the manufacturing method can be applied to the manufacture of a continuous explosive charge, from a plurality of relatively short portions of sheathing material, each of which portions has a length corresponding approximately to the amplitude of displacement of the tube, which method further comprises passing the tube into a first portion so as to effect the introduction of the detonating fuse, withdrawing the tube from the first portion, repeating the procedure until all portions arranged in series are provided with the detonating fuse, making the explosive fuse fast to the far end region of the last portion, filling said last portion with the explosive and optionally diluent as the tube is withdrawn therefrom, securing the distal end region of the adjacent portion to the proximal end region of the last portion, introducing the tube into said adjacent portion, filling said adjacent portion with explosive and optionally diluent as the tube is withdrawn therefrom, repeating this procedure until all portions are joined and filled, and making fast the proximal end region of said first portion to the fuse.

For a better understanding of the present invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:—

Figure 1 is a perspective cut-away view of a portion of an explosive charge according to the present invention;

Figure 2 shows, in axial cross-section, an explosive charge which has been introduced into a hole drilled vertically into a rock;

Figure 3 shows, in axial cross-section, the introduction of a detonating fuse into a flexible sheath during the outward travel of a filling tube of a pneumatic charging device;

Figure 4 shows, on a larger scale, the device for, and method of, advancing the detonating fuse;

Figure 5 shows, in axial cross-section, the charging of the explosive during the return travel of the tube of the pneumatic charging device;

Figure 6 corresponds to Figure 3, except that it relates to the manufacture of long explosive charge from a plurality of short sheaths;

Figure 7 corresponds to Figure 5, except that it relates to the manufacture of a long explosive charge from a plurality of short sheaths; and

Figure 8 illustrates the manner in which a continuous explosive charge can be divided into shorter units.

Referring firstly to Figure 1, there is shown in the continuous explosive charge according to the present invention, an explosive 1 in granulated form, which is lodged within a cylindrical sheath 2 made of a flexible plastics material, and a single detonating fuse 3 extending axially through the sheath 2 and passing out to the exterior, at at least the right hand end 4 where the sheath 2 is made fast to the detonating fuse 3 by means of a ligature 5. The axial position of the detonating fuse 3 in the sheath 2 is not critical, and it is to be understood that it may occupy any other position off the axis of the sheath 2, but within the sheath 2.

Figure 2 shows the continuous explosive charge disposed, with a view to effecting a precutting shot, in a vertically drilled hole 7, the fuse cord 3 extending from the upper end 4 of the sheath 2 and emerging above the hole 7 by a length sufficient to enable it to be joined to neighbouring explosive charges. At its lower end 6, the sheath 2 and the detonating fuse 3 are flush with each other.

The length of the explosive charge is adapted to the depth of the drill hole 7, the annular space between the charge and the wall of the hole optionally being filled with gravel 8 so as to completely surround the charge. The upper region of the drill hole 7, above the explosive charge, is filled with a sand tamping 9.

According to a preferred method, as shown in Figures 3 to 5, the continuous explosive charge is manufactured in unitary lengths ready for use. To this end, the sheath 2 is cut off to the desired length a and is disposed on a work table 11, prior introducing the detonating fuse 3 during a first phase (Figure 3). The filling with explosive 1 of the sheath 2 takes place during a second phase (Figure 5). These two phases are performed successively with the aid of a tube 12 connected to a pneumatic charging apparatus 10 which permits, alternately, the introduction of compressed air alone during the first phase followed by the introduction of explosive 1 during the second phase, under the effect of the compressed air.

In the first phase (Figures 3 and 4), a light weight formed by a wooden washer 13 which is pierced at its centre is engaged on one end region of the detonating fuse 3 and then passed through the orifice 14 formed at one of the ends of the sheath 2. Through the same orifice 14 is also passed the pneumatic tube 12. Under the action of compressed air flowing in through the tube 12, the sheath 2 is progressively inflated and the washer 13 subjected to the pressure of the air as the tube 12 advances, thereby entraining the detonating fuse 3 in the sheath 2. The washer 13 is recovered when it reaches orifice 16 at the other end of the sheath 2 and, at this same end, the detonating fuse 3 and the sheath 2 are joined together by a ligature 5.

The explosive 1 (Figure 5) is then introduced pneumatically through the tube 12. In this second phase, the tube 12 is progressively withdrawn as the charging is effected. When the tube 12 has returned to the inlet orifice 14 of the sheath 2, the latter is ligatured on the detonating fuse 3, which is then severed, leaving sufficient free fuse projecting.

The manufacture of the explosive charge according to the invention is thus effected at the end of the combination of an outward and return travel of the tube 12, the first phase corresponding to the outward travel movement in the direction of arrow f_1 (Figure 3) and the second phase corresponding to the return travel movement in the direction of arrow f_2 (Figure 5).

According to an alternative preferred method, which is illustrated in Figures 6 and 7, the continuous explosive charge is manufactured with the same apparatus, from short lengths of sheathing, supplied in the form of rolls.

A flexible sheath is to be manufactured from sheath portions 22^1, 22^2, 22^3 each of length b which is less than the length of maximum travel of the tube 12 of the pneumatic charging apparatus, the number of such portions 22^1, 22^2, 22^3 .... 22^n, disposed end to end, being a function of the length of the sheath to be obtained.

The portions 22^1, 22^2, 22^3 are laid end to end and, during a first phase, a detonating fuse 23 is succesively introduced into each of the portions 22^1, 22^2, 23^3 during the outward travel movement (in direction f_1) of the tube 12. At the end of each outward travel movement the tube 12 performs an idle return movement through the last portion to be provided with the fuse 23 and is then introduced into following portion 22, together with the fuse 23.

Thus, in Figure 6, the tube 12 and fuse 23 has been passed through portion 22^1, the tube 12 has been withdrawn from portion 22^1, and the tube 12 and fuse 23 are being introduced into portion 22^2. As soon as the last portion (portion 22^3 in Fig. 7) has been provided with the fuse, the left hand end of that portion and the detonating fuse 23 are ligatured and explosive 21 is pneumatically introduced during the return travel movement of the tube 12 in this last portion 22^3. The tube 12 is withdrawn.

Then, during a second phase, the adjacent portion 22^2 is overlapped with the portion 22^3 and adhesively secured thereto. The tube 12 is inserted into portion 22^2 which is then charged with explosive 21; here the tube 12 effects an idle outward travel movement and effects charging during its return travel movement. This procedure is repeated for the remaining portion(s). When the last portion 22 has been charged, its free end is ligatured on the detonating fuse 23 which is left project-

ing by a sufficient length, and then the resulting continuous explosive charge can be rolled up.

As in the manufacture of unitary explosive charges, the introduction of the detonating fuse 23 takes place during the outward travel movements of the tube 12 and the charging is effected during the return travel movements of the tube 12.

In use, a short charge can be obtained from a long continuous explosive charge supplied in the form of a roll. This can be effected by nipping the sheath 25 (Figure 8) firstly at a distance *c* corresponding to the length of the desired charge and secondly at a distance *d* from the first nip, this latter distance *d* corresponding to the length of projection of the detonating fuse 23 which is necessary for the following unitary charge. Between the two nips, in a region 26 the sheath and fuse are severed, the explosive 21 is withdrawn and fresh ligatures 24 are effected at the level of these two nips.

The explosive 1 is preferably a mixture of ammonium nitrate of a quality suitable for the pneumatic charging, and a fuel, for example a domestic fuel, the latter advantageously permitting more complete utilisation of the nitrate oxygen. The fuel, which preferably has a flashpoint higher than 70°C., is generally present in a concentration of 6% by weight of the nitrate, although it can be present as up to 10%. The nitrate is generally present in the form of 1 to 3 mm. diameter grains.

In a preferred embodiment, the nitrate is simply impregnated with fuel; it then retains its granulated form, the grains readily sliding over each other. However, the mixture may also be in the form of a slurry, particularly when the quantity of fuel is larger.

The explosive 1 may be associated with a powdered diluent, for example wood flour. However, it is also possible to use other celluloses in a divided state, sodium chloride and, generally speaking, any other low-cost product suitable for pneumatic charging. The proportion of diluent is generally up to 35% of the weight of the explosive.

The detonating fuse 3 is advantageously a single, flexible fusing weighing 12 g. per metre.

The sheath 2 is advantageously made from a plastics material. In preferred embodiment, the plastics material is polyethylene. However, it would also be possible to utilise any other type of flexible plastics material, for example flexible polyvinyl chloride and copolymers of vinyl chloride and vinylidine chloride.

The diameter of the sheath 2 is generally from 25 mm. to 80 mm., preferably from 30 mm. to 60 mm., so that it is a simple matter to form rolls of divisible explosive charges 50 to 100 m. in length.

According to an advantageous mode of performing the process of manufacture, the amplitude for movement of the tube 12 of the pneumatic charging apparatus 10 is of the order of 20 metres. In this way, it is possible to produce unitary explosive charges of all desired dimensions up to that length, whilst at the same time rapidly producing divisible explosive charges.

Compared with known explosive charges, the explosive charge according to the invention affords a high degree of safety in use, since the explosive 1 cannot of its own accord maintain the detonation. Furthermore, the explosive 1 is inexpensive.

The said explosive charge is introduced very readily into the drill holes (Figure 2) up to an angle of 60° with respect to the vertical without any special precautions, and even into the horizontal or slightly ascending holes with the aid of a bracket-shaped slide serving as a support for the introduction of the charge. Its diameter may furthermore be adapted to all dimensions of the drill holes, since the usual maximum diameter of the sheaths, i.e. 80 mm., is well suited for use in large diameter drill holes, i.e. those of 200 mm. diameter.

Furthermore, owing to its general adaptability, the explosive charge is of advantage in that it dispenses, in the majority of cases, with the introduction of gravel 8.

The explosive charge according to the invention, the cost price of which in itself is low, significantly diminishes the cost of pre-cutting shots within considerable proportions, whilst at the same time permitting operation with the maximum of safety.

The present invention will now be illustrated by the following Example.

Example

In a practical embodiment of the invention, intended for pre-cutting shots effected in a series of drill holes having a diameter of 65 mm. and equidistantly spaced by a distance of 60 cm., and having a depth ranging from 10 to 12 m. and an angle of inclination to the vertical of 45°, use was made of a polyethylene sheath 0.2 mm. thick and 55 mm. wide (measured flat). The explosive was diluted and had the following composition by weight:

finely divided ammonium nitrate, pneumatically charged	85%
domestic fuel, flashpoint higher than 70°C.	5%
celluolse in the form of wood flour	10%

Packed in unitary charges, the explossive charge according to the invention had a diameter of 35 mm. and a linear charge of 760 g. per metre. The detonating fuse was a single, 12 g. per metre fuse.

The unitary charges were used without the

addition of gravel in the residual space in drill holes, with satisfactory results.

The wooden washer 13 used for the advance of the detonating fuse 3 within the sheath 2 may be replaced by a plug or stopper crimped on the end of the fuse 3. Similarly, in the case of the manufacture of continuously long explosive charges from short portions 22^1, 22^2 and 22^3 of sheathing material, the portions can be connected together with the aid of strips or tapes adhesively secured on either side of the junction.

WHAT WE CLAIM IS:—

1. A longitudinally extending explosive charge comprising a flexible sheath, a pourable explosive contained in the flexible sheath, and a detonating fuse extending through the sheath, made fast to the sheath at the end regions of the latter and extending beyond the sheath at at least one end of the sheath.

2. An explosive charge is claimed in Claim 1, wherein the explosive is a mixture of ammonium nitrate and a fuel.

3. An explosive charge as claimed in Claim 2, wherein the explosive is in the form of grains of ammonium nitrate impregnated with the fuel.

4. An explosive charge as claimed in Claim 2 or 3, wherein the fuel is present in an amount of up to 10%, of the weight of the nitrate.

5. An explosive charge as claimed in Claim 4, wherein the fuel is present in an amount of approximately 6% by weight of the nitrate.

6. An explosive charge as claimed in any preceding claim, wherein the flexible sheath is a cylindrical sheath made of a plastics material.

7. An explosive charge as claimed in Claim 6, wherein the sheath is made from polyethylene.

8. An explosive charge as claimed in any preceding claim, wherein the detonating fuse is a single fuse.

9. An explosive charge as claimed in any preceding claim, which further comprises a diluent mixed with the explosive, the diluent being inert or only slightly active and in powdered form.

10. An explosive charge as claimed in Claim 9, wherein the diluent is wood flour.

11. An explosive charge as claimed in Claim 9 or 10, wherein the diluent is present in an amount of up to 35%, of the weight of the explosive.

12. An explosive charge as claimed in Claim 1, substantially as described in the foregoing Example.

13. An explosive charge as claimed in Claim 1, substantially as hereinbefore described with reference to, and as illustrated in, Figures 1 and 2 or Figure 8 of the accompanying drawings.

14. A method for the manufacture of a longitudinally extending explosive charge as claimed in any one of Claims 1 to 11, which comprises introducing into one end of a flexible sheath a tube connected to a pneumatic charging apparatus, feeding compressed air into the sheath through the tube during an outward travel movement thereof, whilst causing the compressed air from the tube to entrain a detonating fuse, and, once the tube has reached the other end region of the sheath, fastening the detonating fuse to the sheath in a region of the other end of the sheath, and withdrawing the tube meanwhile causing it to deliver, during its return travel movement, a pourable explosive and fastening the detonating fuse to the sheath in the region of the said one end of the sheath, and optionally a diluent, so as to fill the sheath.

15. A method according to Claim 14, wherein the advance of the detonating fuse is effected by securing to one end of the said fuse a body which is subjected to the pressure of the compressed air.

16. A method according to Claim 14 or 15, wherein the end region of the fuse emerging from the sheath at the end of the outward travel movement of the tube is made fast to the sheath before the commencement of the return travel movement of the tube.

17. A method according to Claim 14 or 15, suitable for the manufacture of a continuous explosive charge, from a plurality of relatively short portions of sheathing material, each of which portions has a length corresponding approximately to the amplitude of displacement of the tube, which method further comprises passing the tube into a first portion so as to effect the introduction of the detonating fuse, withdrawing the tube from the first portion, repeating the procedure until all portions arranged in series are provided with the detonating fuse, making the explosive fuse fast to the far end region of the last portion, filling said last portion with the explosive and optionally diluent as the tube is withdrawn therefrom, securing the distal end region of the adjacent portion to the proximal end region of the last portion, introducing the tube into said adjacent portion, filling said adjacent portion with explosive and optionally diluent as the tube is withdrawn therefrom, repeating this procedure until all portions are joined and filled, and making fast the proximal end region of said first portion to the fuse.

18. A method according to claim 14, substantially as hereinbefore described with reference to Figures 3, 4 and 5 of the accompanying drawings.

19. A method according to Claim 17, substantially as hereinbefore described with reference to Figures 4, 6 and 7 of the accompanying drawings.

20. A method of obtaining a relatively short explosive charge from a continuous explosive charge as claimed in any one of Claims 1 to

13, which comprises nipping the continuous explosive charge at an appropriate distance from an end region thereof, and severing the continuous explosive charge at a point beyond the nip on that side thereof remote from said end region.

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1281421 COMPLETE SPECIFICATION
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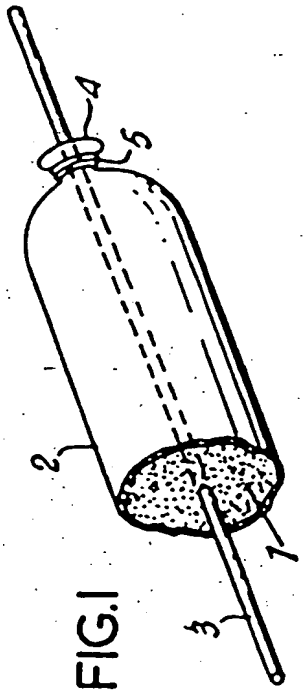


FIG.1

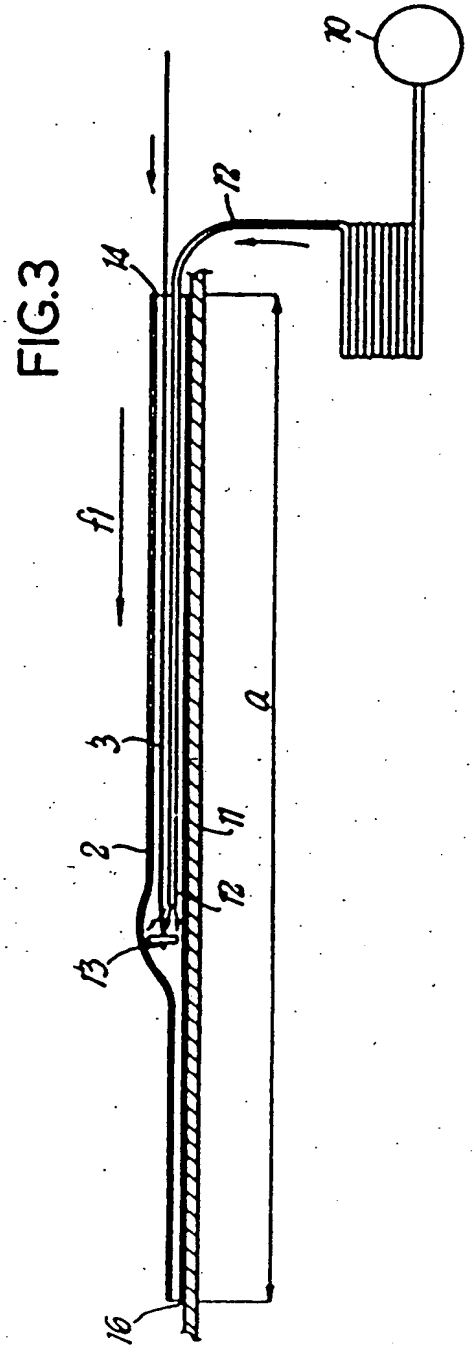


FIG.3

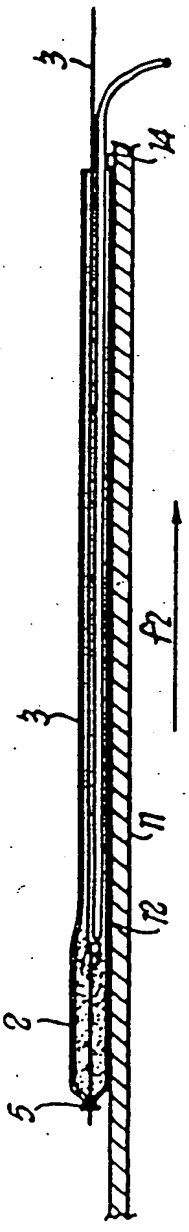


FIG.5

FIG.4

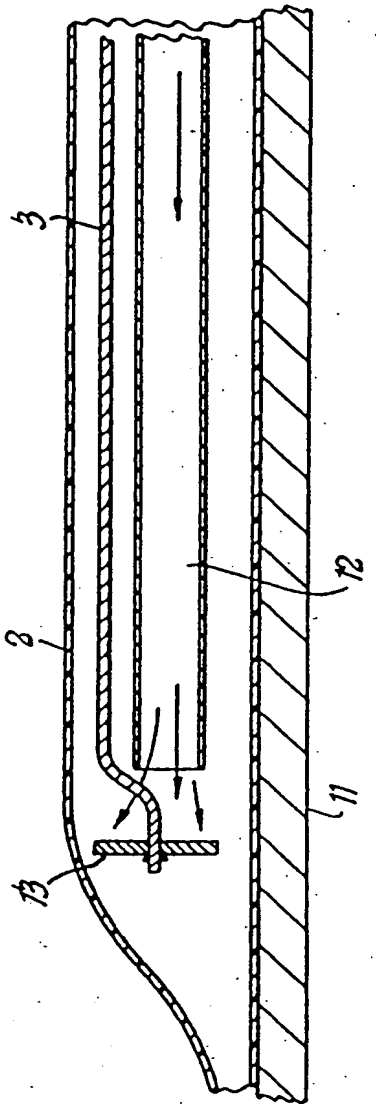
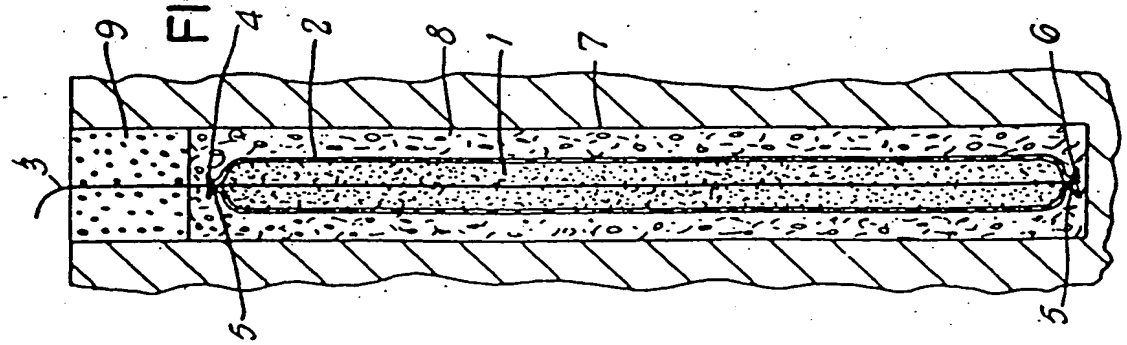


FIG.2



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3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 3

FIG.6

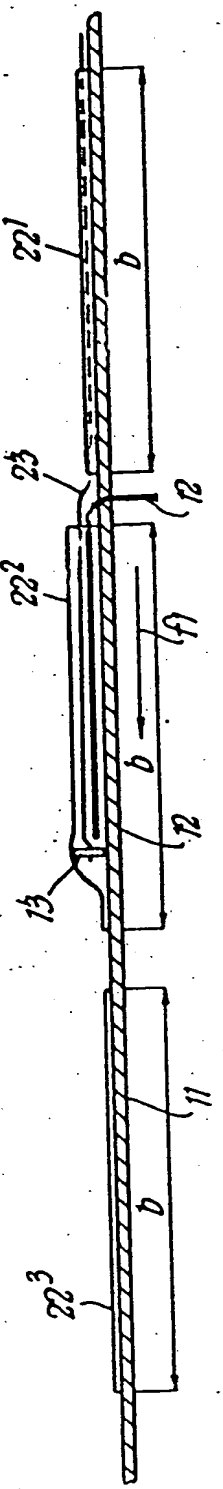

FIG.7

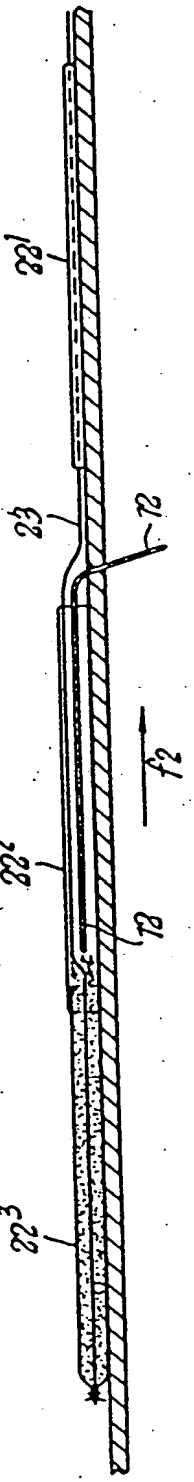

FIG.8